N87-22705

IDENTIFICATION OF LARGE SPACE STRUCTURES:

A STATE-OF-PRACTICE REPORT.

This work was sponsored by the
Edwards Air Force Base, California,
Rocket Propulsion Laboratory.

ASCE TASK COMMITTEE ON IDENTIFICATION OF LARGE STRUCTURES IN SPACE.

COMMITTEE MEMBERS

Prof. M. Kamat, Ga. Tech., Organizer
Prof. E. D. Denman, U. Houston.
Dr. T. K. Hasselman, Eng. Mech. Assoc.
Dr. J. N. Juang, NASA Langley Res. Ctr.
Prof. J. L. Junkins, Tex. A&M U.
Prof. C. T. Sun, Purdue U.
Prof. F. Udwadia, U. Sou. Cal.
Dr. V. B. Venkayya, USAF., Wright-Patterson AFB.

Lt. E. Dale, USAF., Edwards AFB, Monitor
Mr. E. Kippel, ASCE NY, Monitor

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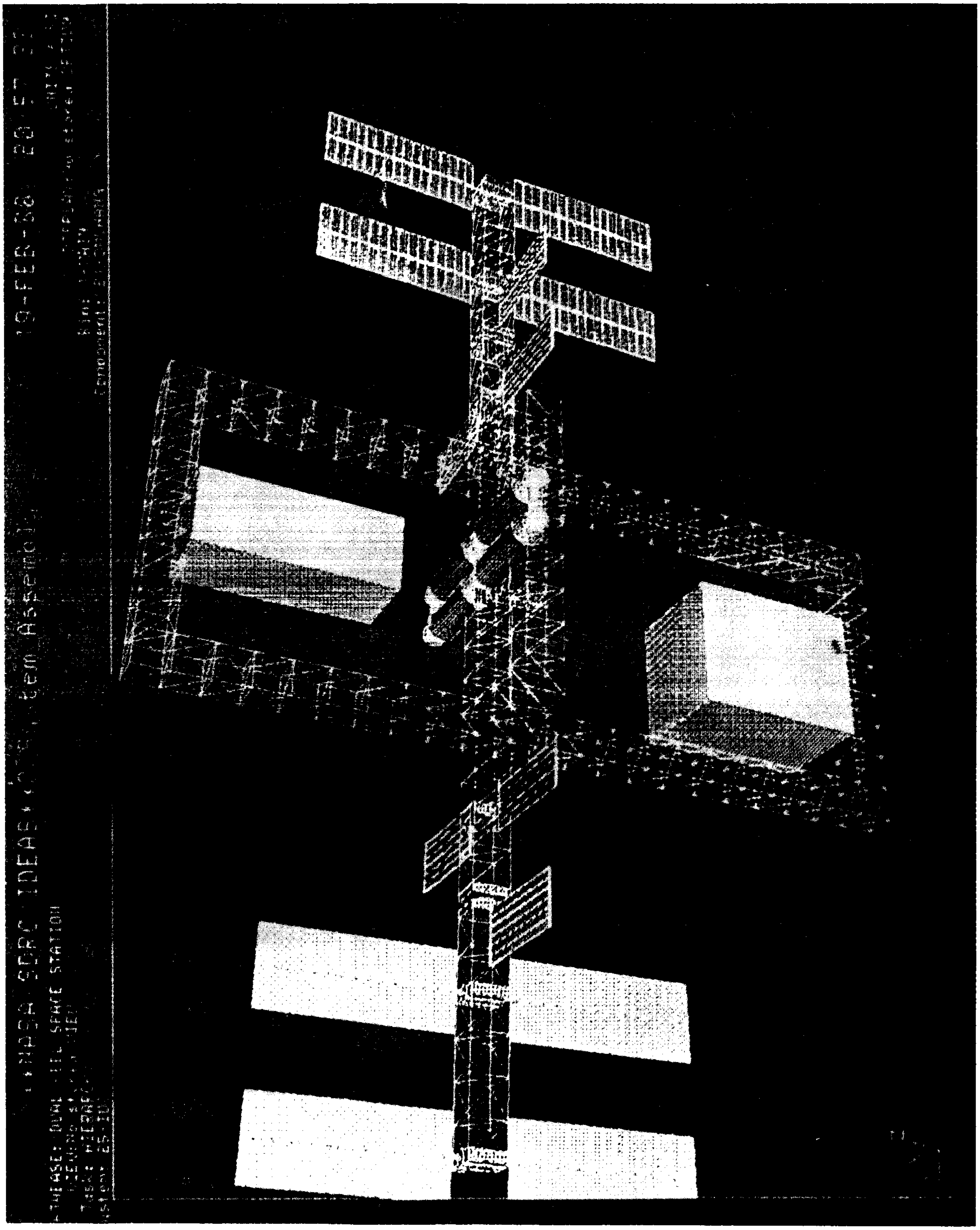
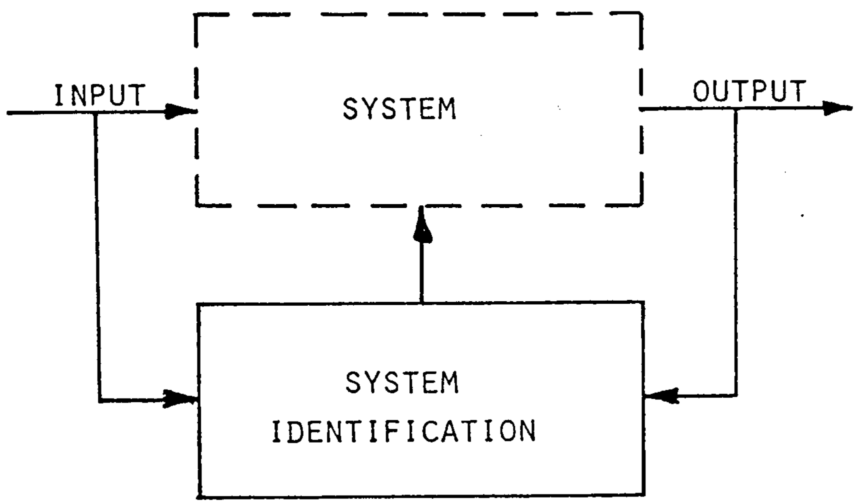
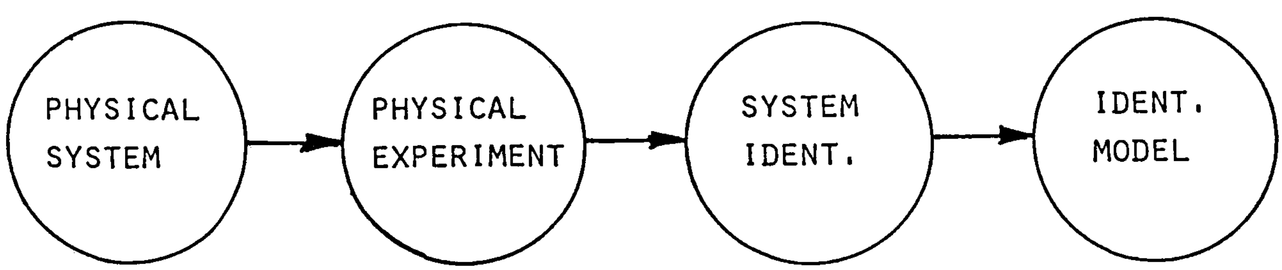


SIMPLIFIED ILLUSTRATION OF THE IDENTIFICATION PROCESS

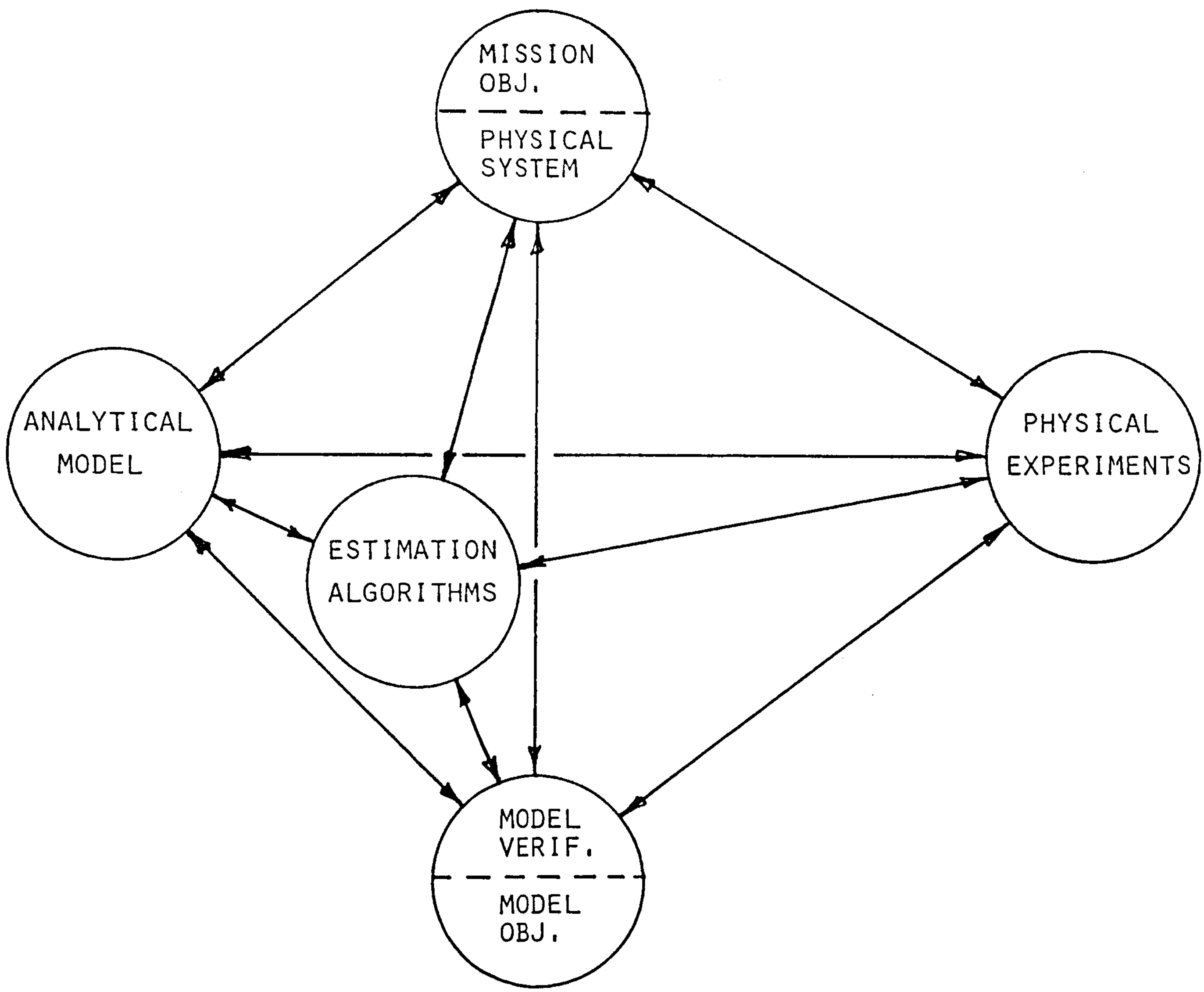
(A) SCHEMATIC FLOW DIAGRAM



(B) LOGICAL FLOW DIAGRAM



LOGICAL FLOW DIAGRAM ILLUSTRATING IDENTIFICATION PROCESS FOR LARGE SPACE STRUCTURES



Task Definition:

I. Structure Model Definition.

Discrete Spatial Structure Model Variables.

$x(t)$=Structure node displacement ($n \times 1$ vector)

$y(t)$=Measured displacement ($l \times 1$ vector)

$f(t)$=Applied force ($m \times 1$ vector)

B=Force actuator matrix ($B \in \mathcal{R}^{n \times m}$)

C=Displacement sensor matrix ($C \in \mathcal{R}^{l \times n}$)

D=Damping matrix ($D \in \mathcal{R}^{n \times n}$)

K=Stiffness matrix ($K \in \mathcal{R}^{n \times n}$)

M=Mass matrix ($M \in \mathcal{R}^{n \times n}$)

A. Matrix polynomial formulation.

Node Displacement Equation.

$$M \frac{d^2 x(t)}{dt^2} + D \frac{dx(t)}{dt} + K\, x(t) = B\, f(t)$$

Measurement Equation.

$$y(t) = C\, x(t)$$

B. State variable formulation.

Node displacements and velocities.

$$\begin{bmatrix} \dot{x}(t) \\ \ddot{x}(t) \end{bmatrix} = \begin{bmatrix} 0 & I \\ -M^{-1}K & -M^{-1}D \end{bmatrix} \begin{bmatrix} x(t) \\ \dot{x}(t) \end{bmatrix} + \begin{bmatrix} 0 \\ M^{-1}Bf(t) \end{bmatrix}$$

$$z(t) = \begin{bmatrix} x(t) \\ \dot{x}(t) \end{bmatrix}$$

$$\dot{z}(t) = \mathcal{A}z(t) + \mathcal{B}f(t)$$

Measurement equation.

$$y(t) = \mathcal{C}z(t)$$

C-2

Controllability and Observability.

Controllability.

System must be controllable for the 2n modes to be excited.

Controllability matrix: $\mathcal{Q}_c = \left[\mathcal{B} \ \mathcal{A}\mathcal{B} \ \mathcal{A}^2\mathcal{B} \ \ldots\right]$

$\mathcal{Q}_c$ must span the 2n algebraic space

Observability.

System must be observable for the 2n modes to be measured.

Observability matrix: $\mathcal{Q}_o = \left[\mathcal{C}^T \ \mathcal{A}^T\mathcal{C}^T \ (\mathcal{A}^T)^2\mathcal{C}^T \ \ldots\right]$

$\mathcal{Q}_o$ must span the 2n algebraic space.

II. Identification of Large Space Structure on Orbit.

A. Identify mass, damping and stiffness Matrices.

B. Identify mechanical properties:

1. Shear rigidity.

2. Bending rigidity.

3. Mass per unit length.

4. Inertia of structure.

III. Verification and Validation of Model.

A. Comparsion to mathematical model.

B. Comparsion to ground testing data.

C. Comparsion of structure dynamics to simulations.

D. Comparsion of dynamics with structure control.

Modelling Errors, and Uncertainities.

I. Modelling errors.

- A. Exact knowledge of properties of materials.
- B. Order of the structure model.
- C. Joint mechanics.
- D. Nonlinearities.
- E. Lack of full structure ground testing.

II. Environment.

- A. Radiation, thermal effects, etc. on structure.
- B. Change of mechanical properties of materials.

Noise, Computations, and Data Collection.

I. Noise.

A. Uncertain forces due to environment.

B. Measurement errors due to finite word length.

C. Noise in data transmission.

II. Computations.

A. Limitation of algorithms for identification.

B. Computational errors, i. e. finite word length.

III. Data Collection.

A. Frequency response of sensors and actuators.

B. Inaccurate location of sensors and actuators.

C. Finite word length of A/D convertors in data collection.

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Tuesday, April 22, 1986

SESSION 2

(Concurrent Sessions on Structures and Control)

Structures Session 2A - Tulon Bullock, Chairman

Active Damping Experiments	G. C. Horner, LaRC
A General Method for Dynamic Analysis of Structures	R. C. Engels, UTSI
Dynamic Behavior of a Large Flexible Space Station During Space Shuttle Orbiter Docking	N. G. Fitz-Coy and J. E. Cochran, Jr., Auburn Univ.
Transient Response for Interaction of Two Dynamic Bodies	A. Prabhakar and L. G. Palermo, MMC

Structures Session 2B - Ronald E. Jewell, Chairman

Mover II - A Computer Program for Model Verification of Dynamic Systems	J. D. Chrostowski, T. K. Hasselman, Eng. Mech. Assoc.
Considerations in the Design and Development of a Space Station Scale Model	P. E. McGowan, LaRC
Verification of Large Beam-Type Space Structures	C. G. Shih, J. C. Chen J. A. Garba, JPL
Verification of Flexible Structures by Ground Test	B. K. Wada and C. P. Kuo, JPL

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